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PROJECT PEBBLE

A STUDY OF MINE AND MINE COUNTERMEASURES OPERATIONS IN GUERRILLA WARFARE (U)

VOLUME I

ASSUMPTIONS, CONCLUSIONS AND RECOMMENDATIONS

MINE ADVISORY COMMITTEE
NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

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This report has been prepared for the Office of Naval Research and presents results of an analytical study carried out by a scientific advisory group organized under the auspices of the National Academy of Sciences–National Research Council, Mine Advisory Committee and the Department of the Navy, Office of Naval Research.

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Project PEBBLE

Mine and Mine Countermeasures Operations In Guerrilla Warfare

Final Report

Volume I

Assumptions, Conclusions and Recommendations

Prepared for the

Office of Naval Research
and the
Advanced Research Projects Agency

by the

Project PEBBLE Study Group
Mine Advisory Committee
National Academy of Sciences-National Research Council

November 1965
Washington, D.C.

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FOREWORD

During its May 1964 meeting, the Mine Advisory Committee received a briefing from A.M. Bottoms of the Weapons Systems Evaluation Group (then of Research Analysis Corporation), and J.M. Seawright of the U.S. Navy Mine Defense Laboratory on the mine countermeasures problem associated with river and canal operations in South Viet Nam. This briefing and further investigations by the Committee indicated that the mine, in many forms and frequently of crude construction, is a favored weapon of the guerrilla and is used consistently against government forces with an effectiveness out of all proportion to the mining effort and cost involved. More disturbing, however, was the realization that the conventional mine countermeasures capability of the Navy, the Army and the Marine Corps, achieved at enormous cost over many years, is virtually useless against a guerrilla mining campaign, and that systems and techniques specially designed to suit the problem were almost nonexistent. It also became obvious that the same could be said about a large percentage of our stockpiled mines.

At the September 1964 meeting, three problems in the field of mine warfare, recommended to the Committee as subjects for intensive study during the Summer of 1965, were reviewed for action. One of these was the overall problem of mine and mine countermeasures operations in Guerrilla Warfare. Since all three problems were of a critical nature, discussions were held with Admiral H. Rivero, Vice Chief of Naval Operations, The Honorable R.W. Morse, Assistant Secretary of the Navy (R&D), Rear Admiral J.K. Leydon, Chief of Naval Research, and Officials of the National Academy of Sciences, in order to determine where the Committee should concentrate its efforts. These discussions resulted in the decision that since the mine and mine countermeasures problems of Guerrilla Warfare were more immediate, the Committee should organize a full-scale study of the problem at the earliest possible time.

With this decision made, A.B. Focke and C.E. Menneken of the Committee agreed to undertake the job of Study Director and Associate Director, respectively, and Project PEBBLE immediately went into the planning phase. The first problem was to determine the required scope of the effort, establish the basic guidelines, and identify those areas requiring the greatest emphasis. It was decided that shallow water coastal mines, river and canal mines, limpet mines, land mines, and their countermeasures would be considered under those conditions typical of Phase II Guerrilla Warfare, and that the major emphasis of the Study would be on the river and canal mining problem. Obviously, a study of this scope would involve areas of interest to, and

under the responsibility of, the Army and Marine Corps, as well as the Navy. The proposed scope and the objectives of the Study were submitted and discussed with representatives of the Office of Naval Research and the Advanced Research Projects Agency. These discussions resulted in a strong endorsement of the proposed scope and the decision that the Study should be conducted under a joint ONR-ARPA sponsorship.

As the planning and organizational phase of the Study progressed, five basic working groups were identified. These were: (1) The Environment Group, (2) The Vehicles Group, (3) The Mines and Mining Group, (4) The Swimmers and Swimmer Countermeasures Group, and (5) The Mine Countermeasures Group. Some sixty-five scientists, engineers and operational officers (representing the Navy, Army and Marine Corps) were carefully selected from the academic, industrial and governmental communities for full or part-time participation in the Study in order to provide each of the working groups with a balanced capability to deal effectively with its assigned task.

Project PEBBLE fully recognized the fact that Guerrilla Warfare differs from Conventional Warfare in many important ways, and that these differences must be taken into account in the design of weapon and countermeasures systems. The following steps taken to prepare the Study Group for its attack on the assigned problems reflect the attention paid to this fact: (A) A select reading list on various aspects of Guerrilla Warfare was prepared by the Special Warfare School at Fort Bragg, North Carolina, and distributed to those participants having lead responsibilities. (B) A three-day briefing covering the political and military aspects of Guerrilla Warfare, as well as the present and planned capability in mines and mine countermeasures applicable to such operations, was held on 4, 5, and 6 May 1965. (C) Four key participants in the Study attended the Senior Officer Counterinsurgency and Special Warfare Orientation Course at Fort Bragg to better prepare them for their leadership roles. (D) A select library of approximately 1000 volumes, covering every aspect of Guerrilla Warfare and the required technical reference material, was assembled from many sources.

The planning and organizational phase completed, Project PEBBLE convened in its assigned facilities at the U.S. Naval Postgraduate School in Monterey, California, on 21 June 1965. The Study was officially terminated on 16 July 1965, with each working group submitting a final report after having presented and defended their conclusions and recommendations to the assembled Study Group. This report represents a summary of these conclusions and recommendations. Volume II of the Final Report will present the detailed analyses and assembled data upon which these conclusions and recommendations were based.

The Project PEBBLE Study Group is deeply indebted to many individuals and organizations for the success of its efforts, with the greatest credit going to the Navy and the Army. Special commendation is due the Project PEBBLE secretarial staff for an excellent performance over many months.

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ASSUMPTIONS AND BOUNDARY CONDITIONS

Guerrilla Warfare* has been the predominant form of armed conflict throughout the world since 1946, with the result that the governments of China, Yugoslavia, Indochina, and Cuba have been defeated and those of Greece, Malaya, Philippines, Algeria, Indonesia, Cyprus, and Kenya have experienced near defeat. Obviously, South Viet Nam now stands in jeopardy. Even a cursory analysis of these conflicts leaves little doubt as to the effectiveness of guerrilla tactics or the enormous military and nonmilitary efforts required for their defeat.

As indicated in Figure 1, there are some 54 countries lying in the tropical and subtropical zones around the world that possess internal conditions making them vulnerable to guerrilla movements. In view of the time required to alter these conditions by peaceful means, it must be concluded that Guerrilla Warfare will continue to be the predominant form of armed conflict throughout the world during the foreseeable future. The major emphasis of Project PEBBLE was, therefore, placed on mine and mine countermeasures systems and tactics having general applicability to Guerrilla Warfare, with the problems in South Viet Nam serving more as a case study than as a primary objective.

Guerrilla wars characteristically have three phases. In Phase I, the guerrilla organization is built and the sympathy and cooperation of the populace is sought. In Phase II, overt acts against the government, such as ambushes and hit-and-run attacks on installations, as well as controlled terror tactics employed against the populace, are prevalent. In Phase III, the guerrilla has gained sufficient strength to assume Conventional Warfare status and to engage the government forces on those terms. Since the use of mines on a significant scale is unlikely in Phase I, and a capability exists to deal with the purely conventional aspects of Phase III, Project PEBBLE restricted its considerations to those tactics and weapons typical of Phase II Guerrilla and Counter-Guerrilla Warfare.

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*For its purposes, Project PEBBLE defined Guerrilla Warfare as the full spectrum of political and military tactics employed by an organized minority against the government and the populace of a country in order to weaken the will of both to resist and for the purpose of furthering its own political goals.

During Phase I and II operations, United States military and civilian personnel will, most likely, occupy an advisory position to the government under attack, and the mine and mine countermeasures systems and vehicles will be operated by the military and civilian personnel of that government. Because the educational and technological level, as well as the materiel base, in those countries vulnerable to guerrilla movements will not equal that of the United States, Project PEBBLE in all cases favored the simpler solution over the more sophisticated, provided the latter did not promise vastly superior performance. In turn, simplicity in use was emphasized over simplicity of design.

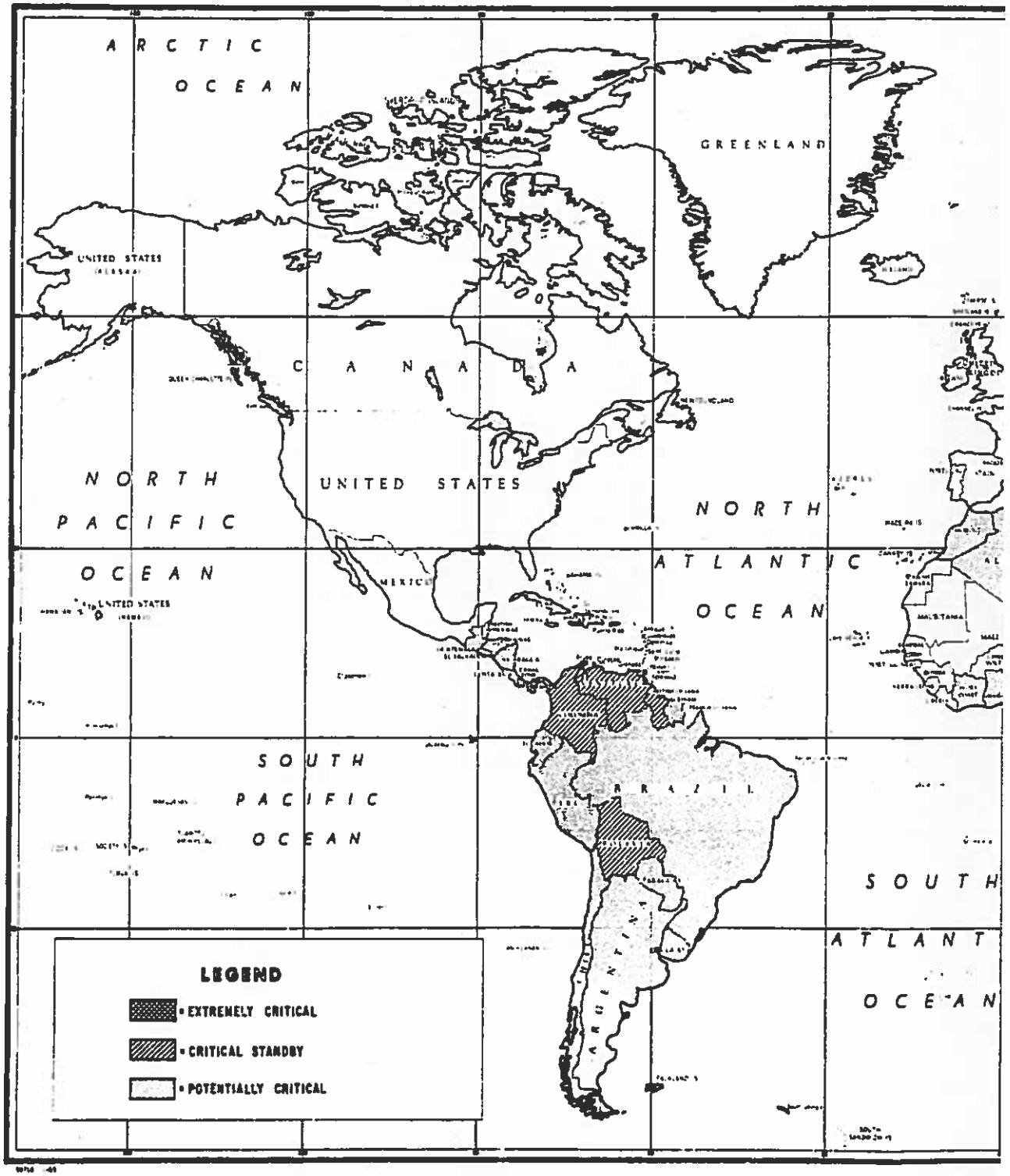
There is extreme variability in mine types and in fabricated explosive devices used in a mine-like fashion by guerrilla forces. Therefore, in order to provide a firm guideline for the deliberations of each of the five working groups, a mine was defined as "a waiting weapon emplaced for a sudden release of energy at a time and in a manner appropriate to control personnel or materiel through destruction, damage, exposure, delay or otherwise."

Under the above definition, four basic categories of mines and their countermeasures were considered: (1) shallow water coastal mines, (2) river and canal mines, (3) limpet mines, and (4) land mines. Based on the assumption that guerrilla forces are not likely to have the proper mines in the necessary number or, indeed, to have the requirement to plant minefields in deep offshore waters, the efforts of Project PEBBLE were restricted to coastal waters less than 50 feet in depth, with the major emphasis of the Study being on river and canal mines and mine countermeasures.

The actual threat posed by mines of the above types came under considerable discussion during the planning phase of Project PEBBLE. An analysis of incident reports from South Viet Nam indicated that over the previous 15 months (January 1964 - March 1965), the river and canal mining incidents had averaged about five per month. The land mining incidents are estimated to have been considerably more numerous over the same period, but data adequate to substantiate this does not appear to be available. To the knowledge of the Study Group there have been only two limpet mining incidents during the past several years.

An analysis based solely on the damage and casualty figures resulting from these incidents would probably result in the conclusion that, at least during Phase II Guerrilla Warfare, the mine does not constitute a major threat. There is, however, a very real danger in such an oversimplified analysis. The effectiveness of a mining campaign has never been measured simply in terms of ship and personnel casualties, but has included the cost

Figure 1. Countries Mo



Susceptible to Guerrilla Activity.

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to the enemy in ships, men, and materiel required to counter the threat, the necessary modification of his tactics, the rerouting of his forces, and the psychological strain imposed on his men.

In evaluating the effectiveness of mines in Phase II Guerrilla Warfare, two points must be kept in mind. First, the guerrilla must of necessity be efficient in his use of materials. It is reasonable to assume that while the Viet Cong may on occasion have been materiel and manpower-limited, they have in the main kept their mining campaign at the level just sufficient to accomplish the desired effect. And secondly, in the hands of the guerrilla the mine assumes more of the attributes of a strategic than a tactical weapon. From the guerrilla's point of view the mine, used singly or in combination with other weapons, is ideally suited to the purposes of controlling movement since the threat rather than the fact is often sufficient.

The control of movement, in which the government forces are increasingly discouraged from frequent contact with large sections of the populace is, in the opinion of Project PEBBLE, the single most important objective of the mine as used by guerrilla forces. Clearly, the Viet Cong have all too frequently achieved this objective. Therefore, Project PEBBLE takes the position that mines, as previously defined, do pose a major threat in Phase II Guerrilla Warfare and should be dealt with on a comparable level.

ENVIRONMENTAL FACTORS

Due to the unique nature of Guerrilla Warfare, it is considered essential that the total environment be taken into consideration in the evaluation of weapons and countermeasures systems and the tactics for their employment. It is useful to break this overall environment into two rather different components. The political, social, economic, and psychological (PSEP) factors rather clearly group themselves together while being quite separate from the physical environment. In view of the large number of countries considered by Project PEBBLE, it was necessary to restrict attention to those factors common to all or most of these areas.

PSEP Environment

Objective. In its simplest terms, the objective of the guerrilla is to over-throw the government in power and to assume control of a country whose economy is left largely intact and whose people bear an attitude not unfavorable to the new government. In pursuit of this goal the guerrilla's political and military aims are intertwined and inseparable, with the political objective taking precedence over the military at all times. In order to counte these tactics successfully, the government obviously cannot afford to be any less concerned and aggressive in the political arena than is the guerrilla.

Due to the recognized importance of this relationship, it was the assigned task of the PSEP Group to evaluate the many real and potential applications of mines and mine countermeasures within the framework of the total requirements, objectives, and tactics of both the political and the military conflict. The conclusions reached by this Group served as inputs to the other working groups rather than resulting in independent recommendations.

Conclusions

1. During Phase II operations, the guerrilla is largely dependent upon arms and ammunition captured from the government forces. This ability to live off the land, so to speak, serves to increase his mobility and flexibility, reduce the cost of his operations, and drastically to reduce his

dependence on long supply lines. However, this dependence upon captured materiel is also a point of vulnerability which can, occasionally is, and certainly should, be taken advantage of at every opportunity. Therefore, no mine employed offensively or defensively against guerrilla forces should be without an anti-tamper device. The fact that this further complicates the mine design and increases the difficulty of the government clearing its own minefields is recognized, but it is believed that the advantages far outweigh these disadvantages.

2. By the very nature of his operations, the guerrilla must have a sanctuary where he can recuperate, plan and coordinate future operations, train his troops, and conduct much of his weapon fabrication. Ideally, the primary sanctuary is just over the border in an adjacent country sympathetic to the guerrilla's cause. In-country sanctuaries, usually in relatively inaccessible places such as mountains or swamps, are also typical. Here again, the sanctuary is a part of the guerrilla's strength, but it is also a point of vulnerability. While he tends to be illusive and dispersed in the field, his position here is better known and his numbers more concentrated. Obviously, he must enter and leave the sanctuary in order to remain effective, and in some cases this is along identifiable routes.

In no case should the guerrilla be allowed the advantages of a sanctuary without extracting the maximum penalty. Barriers, such as the Morice Line used by the French against the Algerian rebels, and in some cases simple minefields, are among the more effective and economical methods of restricting movement over extended areas. The government involved should be strongly encouraged to use such techniques both in and around those sanctuaries not also occupied to a large degree by noncombatants.

3. Mines are frequently used as a part of the perimeter defense around strategic hamlets and other permanent positions. The very real danger of noncombatants accidentally detonating the mines in such fields emphasizes the advantages of developing a controlled field in which the mines can be rendered inactive during the daylight hours. It has been repeatedly demonstrated, however, that such positions frequently fall through betrayal from within rather than by a breaching of their defenses. Therefore, while recognizing the basic advantages of a controlled minefield, it is concluded that such fields should not be used in positions where control cannot be made secure.

4. Since the guerrilla moves within the populace and is, in most cases, indistinguishable from a noncombatant, there is a pressing need for nonlethal "marking" mines which can be strategically placed during curfew hours in order to detect illegal movement.

5. Finally, it should be reemphasized that under Phase II conditions the conflict is actually a dual war made up of a campaign waged on the political front and a campaign waged on the purely military front. These two wars, waged in intimate contact with a populace whose approval and cooperation is sought by both combatants, must be conducted in such a manner as to be mutually complementary. The nature, the objectives, and the requirements of the political war should always be taken into account in the selection of weapons and countermeasures systems, and tactics for their employment.

Physical Environment

Objective. The objective of the Physical Environment Group was to analyze the coastal, inshore and inland waterway environments of those countries considered vulnerable to guerrilla movements, and to identify those parameters which exert a significant influence on the performance of the mine and mine countermeasures systems which are typically encountered and employed in Guerrilla Warfare. In investigating the wide range of environment types represented by the many countries considered, valuable input was provided by the Physiographic Categories Subgroup. The detailed results of this group's efforts will be presented in Volume II of the Final Report.

Conclusions

1. The most likely mine types to be encountered in Guerrilla Warfare are bottom or moored controlled mines and moored contact mines. Because of the low background level in tropical regions, and the likelihood of distinct differences in the magnetic signature of military versus civilian craft, simple magnetic influence mines may be encountered in the future. Acoustic and pressure influence mines are not considered likely. Therefore, consideration was restricted to those environmental parameters which significantly influence performance of the mine types likely to be encountered, and to mechanical and magnetic minesweeping and minehunting.

2. The influence of the environment on conventional mine and mine countermeasures operations, and the value of a prior knowledge of pertinent parameters in the area of interest has been well documented. It is sufficient here to say that while the environmental data required for mine warfare operations in Guerrilla Warfare may be of a slightly different character, they are certainly no less worth knowing.

3. Mindful of the difficulties experienced over the past ten years in attempting to collect badly needed data for the conventional mine and mine countermeasures forces, every attempt was made by Project PEBBLE to restrict the environmental parameters required for guerrilla mine and mine countermeasures operations to those having an obvious and serious effect on system performance. The resulting list of parameters, the environmental regimes to which they apply, and the form and required accuracy of their reporting is presented in Table I.

Recommendations

1. The most reliable method of collecting the required data (as indicated in Table I) in those countries of interest is, of course, by on-the-spot surveys conducted by well-trained environmentalists employing the proper measuring equipment. The difficulty of attempting to openly conduct such surveys in those countries not now involved in active Guerrilla Warfare is obvious but, on the other hand, the collection of needed environmental data should not wait until an ally of this country becomes involved in active counter-guerrilla operations. The following steps are, therefore, recommended:

A. Methods should be sought to encourage each country to conduct its own environmental survey.

B. A small group of environmental specialists should be formed within the appropriate U.S. government agency or laboratory to collect, evaluate, and extract pertinent data (on high priority countries first) from existing classified and unclassified reports, charts, aerial photographs, and personal interrogations. Much of the needed data already is in hand and only requires extraction and tailoring to the needs of mine warfare.

C. Once the United States has been asked to provide technical assistance to a country actively engaged in counter-guerrilla operations, on-the-spot surveys should be strongly advocated or performed as a part of the technical assistance mission.

2. It is recommended that a research program be initiated in U.S. waters as soon as possible to provide badly needed information on vertical and horizontal temperature gradients, and on the acoustic (propagation, reverberation and ambient) characteristics of inland waterways.

3. Finally, it is recommended that the responsibility for the environmental data collection and for the environmental research programs be

centralized under a single group. Because of the Navy's established capability to conduct harbor, channel and offshore environmental surveys for mine warfare purposes, there is considerable merit to having this group housed within the appropriate Naval office or laboratory.

TABLE I

ENVIRONMENTAL PARAMETERS

Required Environmental Parameters	Type Regions* Applicable	Datum and Required Accuracy	Comments
Depth (including tidal depth variation)	A, B, and C	Mean Water Depth ± 1 ft in depths < 10 ft ± 20% in depths > 10 ft	In Type B Regions, MWD need only be reported seasonally with the expected range. In Type C Regions, tidal depth variation need not be reported.
Currents	A, B, and C	Mean Surface Current Velocity ± 1/2 kt for currents < 3 kt ± 1 kt for currents > 3 kt Mean Current Direction (by season) ± 45 degrees	Reported by season. For areas where the Mean Surface Current Velocity is greater than 3 kt, the Mean Current Velocity at a height of 3 ft above the bottom should also be reported. Mean tidal currents should be reported with the same precision for flood and ebb conditions. In Type C Regions, tidal current information need not be reported.
Bottom Characteristics	A, B, and C	Bottom Type classified as rock, gravel, sand mud, shell or coral. Bottom Penetration (using "arm test" for simplicity) reported as none, wrist forearm, elbow, upper arm, or shoulder.	Number of mine-like bottom features (natural or man-made) and those which might obstruct mechanical drags should be reported per mile of track. The likelihood of mine burial by such factors as migrating sand waves, slumps, and scour should be reported where significant.
Acoustic Conditions	A, B, and C	Transmission Characteristics False targets Ambient Noise	Transmission Characteristics (i.e., attenuation, reverberation, backscattering) should be reported for the sonar used on survey. Density of mine-like sonar targets reported in terms of the number of targets per mile of track. Ambient Noise Conditions should be estimated
Visibility (diver)	A, B, and C	Range of Vision at height of 3 ft above bottom. Reported as < 3 ft, between 3 ft and 10 ft, or > 10 ft.	Reported by season
Sea State	A, B, and C	Mean Height of Sea reported as: % of time, height is < 3 ft % of time, height is between 3 ft and 8 ft % of time, height is > 8 ft	Reported by season. In Type B and C Regions, Sea State applies only to large lakes and estuaries.
Swell	A, B, and C	Period of Swell reported as: % of time period < 10 sec % of time period between 10 and 20 sec % of time period > 20 sec	Reported by season. In Type B and C Regions, Swell applies only to large lakes and estuaries.
Fouling Conditions	A, B, and C	Type, degree and rate.	General information should be reported on the likelihood of mine and cable fouling and mine burial due to biological activity.
Electrical Conductivity of the water		Conductivity to ± 30%	Reported by season.

*A. The offshore regime, from the 50-foot contour to the high water mark along the local coast.
B. The tidal regime, including all inshore waters which experience tidal effects.
C. The fresh water regime, including rivers, lakes, canals, etc., above the effect of the tide.

For Type A Regions, data should be presented for such areas as open roadsteads, coastal supply routes, and possible landing areas. For Type B and Type C Regions, data should be presented for key points such as ports, river junctions, major traffic crossings, etc. Insofar as possible, the presentation of data should be such as to facilitate interpolation in order to estimate conditions between key points.

VEHICLES

Objective. The objective of the Vehicles Group was to conduct a comprehensive review of the design, operational and signature characteristics of the vehicles employed by those countries of interest to the Study in order to determine: (1) The vulnerability to different types of mines of those vehicles most likely to be used by the guerrilla. (2) Those vehicles best suited for mine countermeasures operations. (3) Those vehicles exhibiting the least vulnerability to mines. (4) Those practical modifications to existing craft designed to reduce their vulnerability. (5) New vehicle designs tailored to the special requirements of Guerrilla Warfare.

Conclusions

1. Project PEBBLE did not include land vehicles in this area of its investigation since exhaustive studies of mining attacks on such vehicles have been conducted by the Army, just as the Navy has investigated in detail the effect of conventional sea mines on various types of ships. Attention was concentrated on those civilian and military craft and ships typical of countries considered by the Study.

2. The waterborne traffic in likely areas of guerrilla operations is characterized by a rich variety of ships and craft ranging from dugout canoes, log and reed rafts or "balsas," through sampans, junks, dhows and other wooden craft of native and imported design, to steel barges, tugs, fishing craft, coasters and seagoing merchantmen.

Of all areas of the world where "native" types of ships and craft are still in use, the Western and Southwestern Pacific has the greatest variety and number. Some 40,000 Vietnamese junks are estimated to be in the 40,000 square miles of South Vietnamese waters. The great majority of these are sail-powered.

South America has far fewer native water craft designs than other areas of the world. Most are dugout canoes, reed and log rafts or "balsas" and sewn bark canoes, all less than 30 feet in length.

In Africa, India and the Near East, dhows form the principal group of native craft. Very limited data are available for these craft and a great deal

more are needed. Like junks, dhows are largely sail-powered.

3. A review of the characteristics of naval craft available to those countries of concern to Project PEBBLE, indicates that more than half are ex-U.S. Naval craft, with patrol and landing craft types predominating.

4. In Phase II operations, the guerrilla will most likely employ small native craft (under 30 feet in length) of the dugout, sampan or balsa raft type. Since the magnetic and pressure signatures of such craft are close to the vanishing point, and the acoustic signature will be low even when an outboard motor is used, moored contact or controlled mines offer the most effective method of attack. Specific test data are not available, but in view of the simple yet rugged structure of these craft, it does not appear worthwhile to consider smaller explosive charges to produce effective damage to one of these craft than would be required to damage a more complex boat of 30 foot length or more.

5. An analysis of the vulnerability of junks and other native craft of wooden construction to incendiary mines indicates that while the hulls do not present particularly attractive targets, because of their low surface-to-volume ratios and generally waterlogged condition, the sails, deck houses, deck cargo, hatch covers, etc., are vulnerable to such mines. The crew (3 to 14 typically aboard junks) is usually housed above deck and is, of course, vulnerable to an air blast. Of the possible types of incendiary mines, it appears that one set to burst 10 to 30 feet above the water would be most effective. It should spread a cone of incendiary material over an area at least 50 feet in diameter.

6. The dimensional, magnetic, acoustic and flammable characteristics of a wide variety of ships and craft were summarized and tabulated for use by the Mines and Mining Group and the Mine Countermeasures Group. A study of explosion resistance and vehicle vulnerability was undertaken to describe in parametric form the damage produced on these craft by various types of underwater explosions. Noncontact attacks by bottom mines with explosive weights up to 2000 pounds and contact attacks with explosive weights up to about 100 pounds were considered. Limiting curves for hull damage and shock damage were prepared for noncontact attacks. The effects of contact attacks were described in terms of the area of the hole produced in the hull. In many cases, information available is inadequate or completely lacking. The results of these investigations will be reported in Volume II of the Final Report.

7. Present mine countermeasures craft for river and canal work were designed for other purposes and adapted to their present task. Project PEBBLE concluded that there is a need for a small mine countermeasures craft especially designed to meet the requirements of the mining problem in narrow waterways. Such a craft should be resistant to mine explosions, and virtually unsinkable even if severely damaged.

A design of the smallest craft having the required characteristics was undertaken in order to identify the problem areas and to provide a suggested approach. As shown in Figure 2, the resulting design is for a 36-foot craft, with a draft of 2-1/2 feet and a displacement of 38,000 pounds. High explosive resistance is provided by a water-backed hull as shown in Figure 3, and high resistance to sinking is provided by having all remaining space filled with a foam material. Propulsion is provided by two Murray and Tregurtha Units (Model H5DM-3-53) which are very rugged diesel-burning outboard motors having a combined shaft horsepower of 116, and permitting a free route speed of 6-1/2 knots for the craft as designed. The outboard motors as well as the deck housing are rigged with yield-type mounts to reduce shock damage.

Recommendations

1. It is recommended that two of the 36-foot craft discussed above be built and tested for explosion resistance and suitability for the role of a precursor river minesweep craft.

2. It is recommended that stock, double-shell hulls such as the 16-foot Boston Whaler be investigated as a possible expendable precursor craft for river and canal minesweep operations.

3. The feasibility of a joint government-industry development program for light-weight, high-thrust-at-high-slip outboard engines should be investigated.

4. The "Junk Blue Book" for Vietnamese craft is an extremely valuable publication. A similar study should be made of the hull characteristics and construction details of the dhows of the Persian Gulf, Arabian Sea and Red Sea.

5. It is recommended that a series of experiments be conducted to fill the gaps in current data on explosion effects from underbottom attacks, and the effectiveness of various incendiaries on steel, wooden- and plastic-hulled ships in the 20 to 1000 ton class.

6. Finally, it is recommended that the underwater explosion resistance of rubber floats made from deflatable fuel tanks be determined. Such floats may prove useful as supports for precursor booms on minesweeping craft.

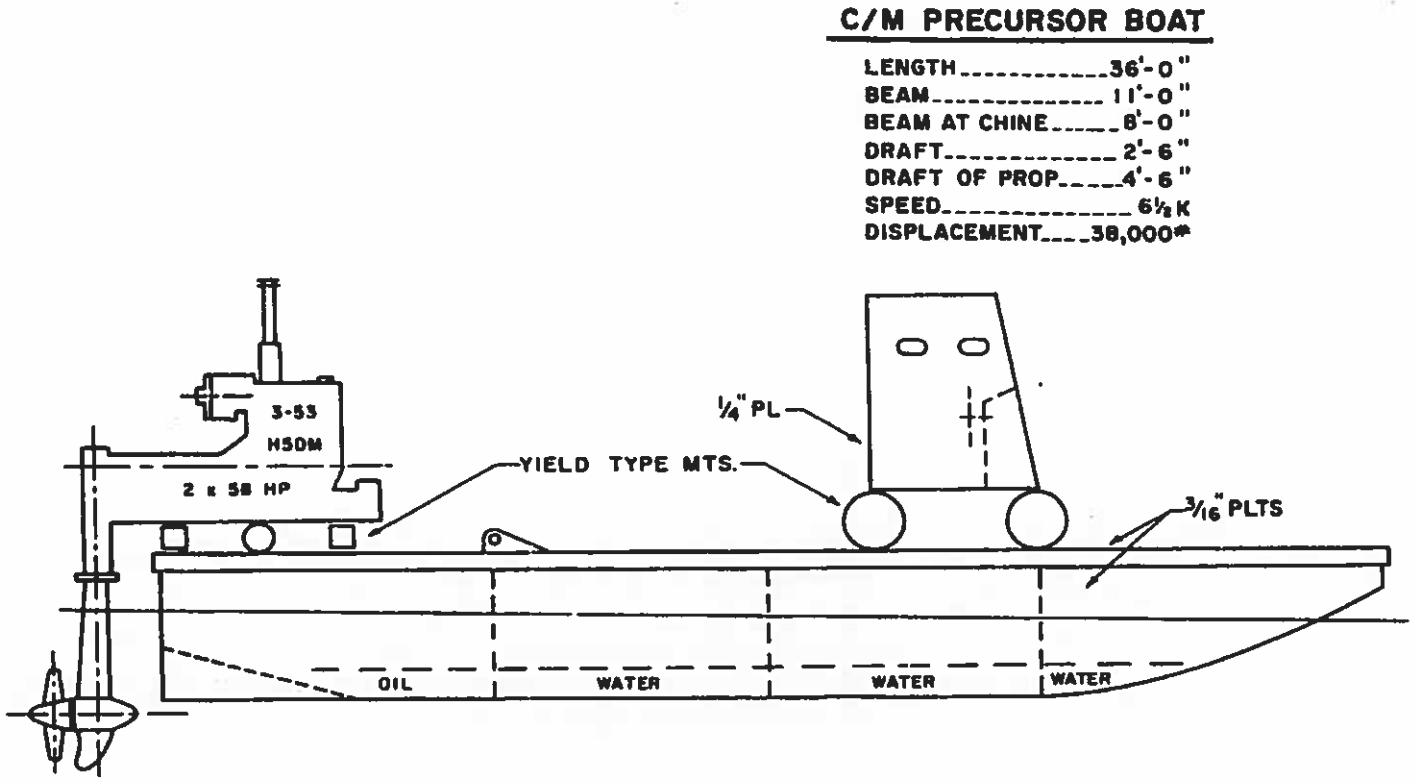

Figure 2. Basic Design Features of a 36-Foot Mine Countermeasures Precursor Boat.

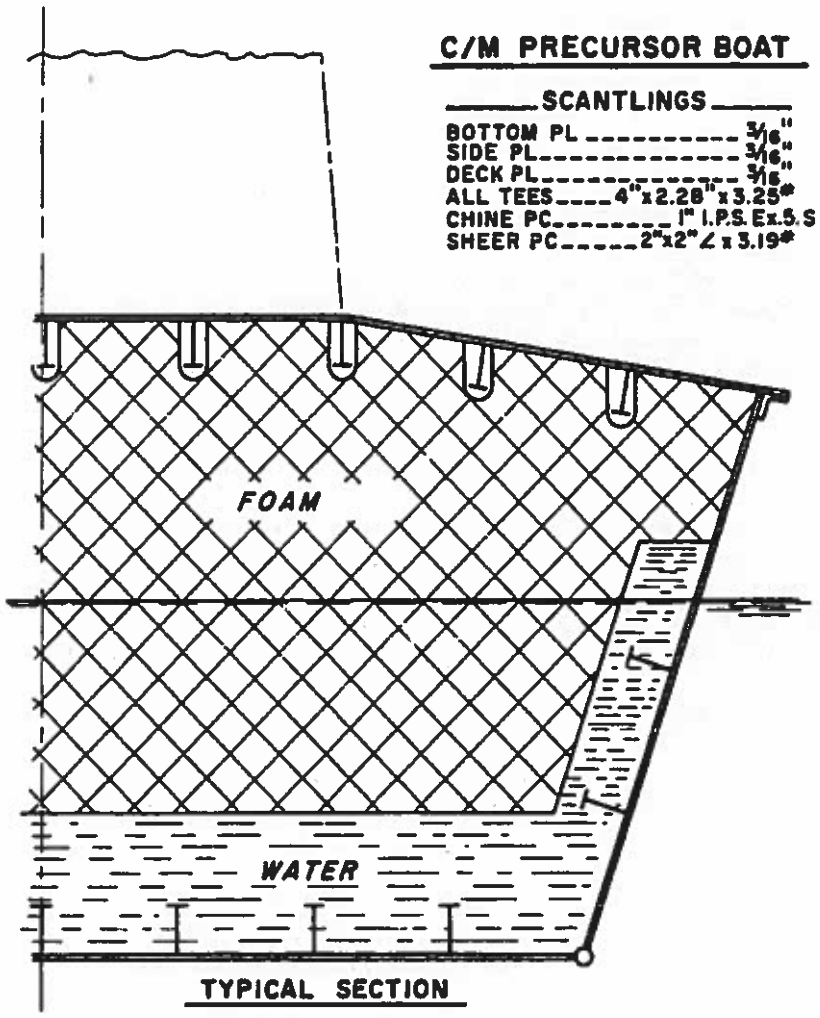

Figure 3. Cross Section of the 36-Foot Mine Countermeasures Precursor Boat Showing Water-Backed Hull and Foam Emplacement Area.

MINES AND MINING

Objective. It was the objective of the Mines and Mining Group to investigate the characteristics of guerrilla targets which lend themselves to attack by mines, and to determine existing, modified, or new mine designs best suited to such attack under the conditions and limitations imposed by the type of warfare under consideration.

Conclusions

1. Mines, as previously defined, have played a highly important role in every guerrilla war in recent times, and for very practical reasons. As used by guerrilla forces, mines can be easily fabricated from a variety of readily available materials; they are ideally suited to their role in the immobilization of land and waterborne convoys as the first step in an ambush; they afford a higher degree of concealment and personal safety for the operator than competing weapons; they leave no telltale weapon to be carried away when contact is broken; when properly used, they have a terror factor unequaled by other available weapons, and; with the firing control in the hands of an operator, the guerrilla mine has a target selectivity which exceeds that of the most sophisticated conventional mine firing mechanism. As Che Guevara stated in his treatise on Guerrilla Warfare,* "The practice of concealing guerrilla groups along roads to explode mines is most remunerative as to equipment and weapons; the surprised enemy does not use his ammunition and does not have time to escape. Thus, the guerrillas obtain considerable results at little cost."

2. The use of mines by government forces in recent guerrilla wars has been restricted, for the most part, to defensive applications, i.e., as one of several defensive measures in barriers such as the Morice Line built by the French in Algeria, and those around fortified positions such as the strategic hamlets in South Viet Nam. This difference in the degree and nature of mine utilization by government and guerrilla forces has been understandable. The variety and number of targets available to the guerrilla are far greater and, in most cases, these targets are conveniently restricted to narrow roads and waterways. The mining targets available to the govern-

*Guevara, Che. Guerrilla Warfare. New York: Monthly Review Press, 1961.

ment forces are largely restricted to the guerrilla himself, and he rarely uses well defined routes on a repetitive basis.

The difficulties inherent in the offensive use of mines against a relatively small and illusive guerrilla force operating within a populace which must be protected, are apparent. However, Project PEBBLE takes the position that the government should be strongly encouraged to pursue a vigorous and imaginative mining campaign against the guerrilla at every opportunity. The potential benefits from the offensive use of mines are too great to be lost because of the recognized difficulties. It should be emphasized that, except under rather special circumstances, the guerrilla is just as restricted by the requirement to protect the noncombatant in the course of his mining campaign as is the government.

3. In order to prevent recovery and reuse by the guerrilla, all mines planted by the government forces should include an anti-tamper device. Mines not easily relocated and recovered (or detonated) should be self-destroying rather than self-sterilizing, and moored mines should be designed to destroy themselves if the mooring cable breaks. In addition, all mines employed by the government should be simple in use. This does not preclude sophisticated design, but it does require that such mines approach fixed ammunition in their requirement for adjustment or assembly by the user.

4. In determining the source and characteristics of guerrilla mines and explosives, it was found that the explosive most easily available in large quantities in practically every country considered is ammonium nitrate fertilizer. While ammonium nitrate is a rather weak explosive by itself, if a material such as fuel oil, lubricating oil, coal dust, etc., is added to it, the result is a mixture with perhaps 20 per cent more energy than TNT. The explosive properties of this material have been published in sabotage instructions which are in guerrilla hands. Project PEBBLE, therefore, concluded that either substitute fertilizers such as ammonium sulphate or phosphate should be sent to these countries, or rather elaborate precautions taken to safeguard delivered ammonium nitrate if this proves impractical.

5. In the course of the Project PEBBLE Study, serious deficiencies were observed in the methods by which counter-guerrilla weapons are developed, and the administrative and budgetary controls restraining such weapon development. Very few standard mine types can be used at all without modification, and these are usable only in a narrow range of tactical situations. Beyond these standard types there are a very few in development which will be of use in Guerrilla Warfare, but even here the development is slow and in some cases funding is uncertain or intermittent. The Army's GRAVEL mine

appears nearest to adoption for service use; the Air Force's DRAGONTOOTH mine is in an early stage of development; effort on the Navy's DENEYE has been temporarily suspended; and the funding for ARPA's ROCK mine is deemed to be about half sufficient. Several proposed mine types which appear to have good tactical applications remain unfunded.

The present system of weapon development almost precludes the design and production of any item that is not substantially universal in its usability. Under non-emergency conditions this would appear to be quite worthwhile, but withholding needed items from the field while they are being made applicable throughout a rigidly imposed range of hypothetical environments does not appear to be justified. Project PEBBLE strongly suggests that these problems be reviewed by all of the services involved in Counter-Guerrilla Warfare and that remedial steps be taken as soon as possible.

Land Mines

The adequacy of available and developmental land mines for various tactical situations is presented in Table II. As indicated, deficiencies exist in available mines for (1) "Defense of Temporary Sites," (2) "Attack on Personnel in Their Areas," and (3) "Attack on Vehicles." The "Contemplated Hardware" columns in the Table indicate that these deficiencies may be satisfied, but there is no indication as to the time of availability.

Recommendations

1. Flexibility in user options at the local command level is badly needed to suit rapidly varying tactics. This indicates the need for a wide variety of mines as well as mines having multiple tactical applications. Along these lines we recommend that:

A. The effectiveness of the M18 CLAYMORE and the M16 BOUNDING mine be increased by the provision of a more versatile firing control.

B. The GRAVEL, DRAGONTOOTH, DENEYE, and ROCK mines are all in the development stage and should be adequately supported. All are badly needed and none have technical problems which cannot be solved.

C. Provisions should be made for the use of artillery shells, bombs, etc., as improvised mines, and troops should be trained in techniques of effective use.

TABLE II

COUNTER-GUERRILLA TACTICS WITH LAND MINES

TACTIC OF EMPLOYMENT	AVAILABLE HARDWARE		CONTEMPLATED HARDWARE	
	Designation Charge Weight and Effect	Fuze Function	Designation Charge Weight and Effect	Fuze Function
Anti-Personnel: Defense of permanent sites and bases (3), (5), (6)	M2-0.34 lb bounding frag M16-1.5 lb bounding frag M18-1.5 lb CLAYMORE M14-1 oz blast M44 bounding flare M48 bounding chute flare M25 1/2 oz, shaped chg.	Press., trip wire Press., trip wire Elec. wire, trip wire Pressure Press., trip wire Press., trip wire Pressure	XM22-12 gm GRAVEL XM617 bounding frag M18-1.5 lb CLAYMORE	Press., long term fabric decay Remote arming control, multiple sequential firing Remote control or linear switch
Defense of temporary sites (troops in field, withdrawal of our troops) (1), (2), (4), (5), (6)			XM27-12 gm GRAVEL XM28-12 gm GRAVEL XM617 bounding frag DENEYE II-0.7 lb frag ROCK-0.5 lb blast DRAGONTOOTH-1 oz blast Army Tilt mine-6 oz blast/frag	Press., 10-15 hr. decompose Press., 12 hr. decompose Remote control multiple firing Pull wire, anti-disturb, self-destroy Anti-disturb, self-destroy Chemical self-decompose Anti-disturb, booby trap
Attack on personnel in their areas (1), (2), (5), (7)	M83-BUTTERFLY 2 lb blast/frag	Anti-disturb	XM27-12 gm GRAVEL XM28-12 gm GRAVEL DENEYE II-0.7 lb frag ROCK-0.5 lb blast DRAGONTOOTH-1 oz blast Army Tilt mine-6 oz blast/frag	Press., 10-15 hr. decompose Press., 12 hr. decompose Pull wire, anti-disturb self-destroy Anti-disturb, self-destroy Chemical self-decompose Anti-disturb, booby trap
Anti-Vehicle: Attack on vehicles (interdiction of fleeing enemy or supply routes) (1), (2), (4), (5), (7)			XM34-3.6 lb blast DENEYE II-0.7 lb frag DENEYE I-10 lb linear shaped ROCK-0.5 lb blast M21 w/XM615 fuze-11 lb Misznay Schardin ATLM-5 lb Misznay Schardin	Pressure Anti-disturb, pull wire Press., self-destroy Anti-disturb, self-destroy Mag. infl., self-sterilize Mag. infl., self-destroy

NOTES:
(1) All unattended mines must be fused so as not to be recoverable for use by guerrilla.
(2) Anti-disturbance fuses should contain a self-destroying device.
(3) Nonlethal mines for warning and revealing are desirable (flares, "fougasses," noisemakers).
(4) Tanks are considered unlikely counter-guerrilla targets. Standard anti-tank mines refused for trucks and for requirements of notes (1) and (2) are applicable. Many anti-personnel mines are effective against trucks.
(5) Waterproofing of mines and fuses for shallow water performance (fords, tidal flats) is desirable.
(6) Nonlethal marking mines could reveal covert activity.
(7) Air emplacement required (low level desired for fixed-wing aircraft).

D. Foreign weapons should be carefully evaluated for their possible use.

2. Better fragmentation mines for anti-personnel and anti-vehicle use are badly needed and can be easily provided with present knowledge.

3. Mines and fuzes for use in wet environments should not require waterproofing by the user. Land mines should be capable of submersion in up to three feet of water as a matter of basic design.

4. Nonlethal warning and marking mines are needed for use in areas where civilian traffic cannot be effectively prohibited. We recommend that a more obvious marking technique than that provided by the TIARA system be developed.

Shallow-Water Mines

The presently available shallow-water mines which are directly applicable to certain Counter-Guerrilla Warfare situations, and those which can be made available after the indicated modifications are listed in Table III. As shown, most require modification. This point is further emphasized by Table IV which shows those mines "Available" and "Not Available" for use against likely targets under various physical and political situations. Obviously, some combat situations are beyond the current or planned capabilities of the United States and those of its allies that might become involved in Guerrilla Warfare.

Recommendations

1. A small moored contact mine of simple design for use in depths less than 20 feet mean low water should be developed. For many of the targets that may be encountered in Counter-Guerrilla Warfare, the charge size in available or developing mines is excessive. A scaled-down version of the 115-A Destructor would appear to be adequate for such targets.

2. Support for the development of a sensitive magnetic actuator for the 250 pound G. P. Bomb should be continued at an adequate level.

3. In certain coastal and delta areas of many of the countries investigated by Project PEBBLE, the tidal range is such that large tidal flats exist at low tide. These areas, in turn, are navigable by shallow draft boats

at high tide. Such tidal flats are likely to be favored routes for guerrilla movement since no presently available or planned mine will function effectively in this environment. It is recommended that the feasibility of an anti-personnel and anti-boat incendiary mine employing a rocket boost for air burst be investigated. The mine would be buried in the bottom for concealment at low tide. Actuation could be either by direct control from the bank or by camouflaged contact wire.

4. Two limpet mines, each having a five pound HE charge, are presently available to our swimmers. Balsa and styrofoam floats are used to buoy these mines to the one-half pound negative that the swimmers prefer. It is recommended that a thorough investigation be made of the feasibility of using a "Limpet Multiplier" — a float filled with a volatile organic liquid such as ethylene oxide (FAX) to provide the needed buoyancy, and which, when quickly volatilized and mixed with the air within the ruptured skin of the target vessel, would provide additional explosive energy. Theoretical calculations indicate that the amount of FAX required to provide the needed buoyancy (27 pounds), when volatilized and in an explosive mixture with air, will yield the energy equivalent to 147 pounds of TNT.

TABLE III

AVAILABLE OR NEARLY AVAILABLE MINES SUITABLE FOR SHALLOW WATER APPLICATION

Ref No.	Mine	Available And Applicable	Total Weight	Charge Weight And Type	Laying Means	Location Main Charge	Actuation Type	Suggested Modification
1a*	M15 Army Anti-Tank (with experimental fuze XM610)		50 lb	22 lb Comp B	Surface Craft	Bottom	Contact	(1b) Used in pairs with one fuze.
2a	M19 Army Anti-Tank (with experimental fuze XM610)		28 lb	11 lb Comp B	Surface Craft	Bottom	Contact	(2b) Used in pairs with one fuze.
3	115-A Destructor		120 lb	45 lb HBX	Air and Surface Craft	Moored	Contact	(3a) Add self-destroy feature to operate immediately in land planting from air, later in water planting. (3b) As in (3a) with lighter charge and anchor.
4	Inland Waterway Boat Mine		35 lb	18 lb TNT	Surface	Moored	Contact	(4a) Mine and anchor packaged for air laying. Note: May fail against target faster than 12 kt.
5	Mk26 Limpet	X	6 lb U/W	5 lb HE	Swimmer		Time delay firing (Mk23)	(5a) Lighter modification for easier underwater transport and handling and with anti-tamper fuze.
6	Mk16 Limpet	X	6 lb U/W	5 lb HE	Swimmer		Time delay firing (Mk23) and anti-tamper device (Mk24)	(6a) Lighter modification for easier underwater transport and handling.
7	Mk135 Demolition outfit	X		20 lb C-3	Swimmer		Various	(7a) Added range in variability to own missions.
8a	G. P. Bomb		250 lb	110 lb HE	Air and Surface Craft	Bottom	Magnetic influence	
9a	Mk6, Mod 14		1400 lb	900 lb HBX-1	Surface Craft (with tracks)	Moored	Contact with anti-tamper fuze	
10a	Mk36		3100 lb	1360 lb HBX-1	Air and Surface Craft	Bottom	Magnetic and Acoustic influence with anti-tamper fuze	Note: Modified by use of M12, Mod 0 components - see 11a.
11a	Mk40, Mod 0		452 lb	210 lb HBX-3	Air and Surface Craft	Bottom	Acoustic influence	
12a	Mk42, Mod 2		1370 lb	625 lb HBX-1	Air and Surface Craft	Bottom	Magnetic influence with anti-tamper fuze	
13a	Mk41, Mod 0		1200 lb	475 lb HBX-1	Air and Surface Craft	Bottom	Magnetic and Acoustic influence with anti-tamper fuze	Note: Mod 2 Mk10 Firing Mechanisms in cascade with special cable plug and new cabling. Acoustic channel provides triggering for sensitive magnetic firing. Normal acoustic dead period is used as live period.
14a	Mk42, Mod 7		1370 lb	625 lb HBX-1	Air and Surface Craft	Bottom	Magnetic influence improvement on Mod 2 with anti-tamper fuze	
15a	Mk39, Mod 2		2100 lb	1200 lb HBX-1	Air and Surface Craft	Bottom	Magnetic influence with anti-tamper fuze	
16a	Mk55, Mod 7		2100 lb	1200 lb HBX-1	Air and Surface Craft	Bottom	Magnetic influence improvement on Mod 2 with anti-tamper fuze	
17	Mk59, Mod 0	X	500 lb	50 lb HE	Surface Craft	Moored	Contact	

*Number accompanied by "a" in Reference Number column indicates that mine has been or is being modified, making it suitable for further counter-guerrilla situations. Number alone indicates mine has not or is not being modified. The use of "b" in Suggested Modifications column indicates changes which would make the mine suitable or more suitable for counter-guerrilla situations. See Table IV.

TABLE IV

PRESENT STATUS OF SHALLOW-WATER MINES SUITABLE FOR USE AGAINST SPECIFIED GUERRILLA TARGETS

TARGET TYPES	SITUATION		MINES[1]		TARGET TYPES	SITUATION		MINES	
	Physical	Political	Available[2]	Not Available[3]		Physical	Political	Available	Not Available
Junk[4]	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	P[5]		1a, 2a, 3b, 4a 3b, 5a, 8a, 9a, 12a	Patrol Boat[9]	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	F		13a
	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	H[6]		1a, 2a, 3b, 4a 4a, 6a, 9a[7], 12a		Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	H		13a
	Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	F	17	1a, 2a, 3b, 4a 8a, 9a, 12a		Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	F		
	Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	H		1a, 2a, 3b, 4a, 8a 8a, 9a, 8a, 10a, 12a, 14a		Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	H		1a, 2a, 3b[10], 4b, 8a, 10a, 13a 3b[10], 4b, 9a, 10a, 13a
	Rivers and Canals	F H	5, 6, 7	1a, 2a, 3b, 4a, 8a 8a, 9a		Rivers and Canals	F H	5, 6, 7	1a, 2a, 3b[10], 4b, 8a, 8a, 9a
	Inner Harbor	H	5, 6, 7	8a, 8a, 9a		Inner Harbor	H	5, 6, 7	8a, 8a, 9a
Sampan[10]	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	F		1a, 2a, 3b, 4a 3b, 5b, 8a, 8a, 12a	Merchant Ship[11]	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	F		3a, 10a, 11a, 12a, 14a
	Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	H		1a, 2a, 3b, 4a 8a, 8a, 12a		Coastal Waters 2 ft - 20 ft 20 ft - 50 ft	H		3a, 10a, 11a, 12a, 14a
	Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	F	17	1a, 2a, 3b, 4a, 8a 8a, 8a, 8a, 10a, 13a, 14a		Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	H		3b, 8a, 11a, 12a, 14a 3a, 10a, 11a, 12a, 14a
	Harbor Channel 2 ft - 20 ft 20 ft - 50 ft	H		1a, 2a, 3b, 4a 8a, 8a, 8a, 10a, 12a, 14a		Inner Harbor	H	5, 6	8a, 8a
	Rivers and Canals	F H		1a, 2a, 3b, 4a					
	Inner Harbor	H							

(1) Numbers refer to entries in Table III.
(2) Standardized as to design and stockpiled to any extent.
(3) Standardized as to design for Conventional or Guerrilla Warfare but requiring modification, as indicated by added lower case letter in Table III.
(4) Any indigenous water craft of the Far East having a wooden hull, 4 inches thick or more, with many compartments intended to be watertight. Draft 2 ft to 6 ft, speed up to 6 kt.
(5) P for favorable, that is under continuous, or nearly continuous, control by government forces. Mining by government forces is for confinement of traffic to continuously patrolled lanes where inspection for illicit personnel and materiel is strictly enforced.
(6) H for hostile, that is under continuous, or nearly continuous, control by guerrillas. Mining by government forces is for harassment in transit, for temporary denial of exit or entrance with respect to harbors or beaches, and by swimmers for individual attack on known targets in known position.
(7) Usable only in the deeper part of this category.
(8) Any small indigenous craft having thin hull and no effective compartmentation. Draft 2 ft to 5 ft, speed 6 kt to 12 kt. No important influence signature except a magnetic signature if loaded with ferrous munitions.
(9) High speed boats with combat effectiveness, having powerful engines. Draft 6 ft to 7 ft, speed up to 35 kt. U.S.N. PC-6 and U.S.S.R. KOMAR are examples. Appreciable acoustic and magnetic signatures.
(10) May fail against target faster than 12 kt.
(11) Cargo ships usually steel-hulled and of drafts suitable for harbors or offshore unloading to boats. Three types may be distinguished: A. Draft 18 ft to 30 ft, 6300 tons to 12,000 tons. B. Draft 14 ft to 20 ft, 2600 tons to 6400 tons. C. Draft 6 ft to 12 ft, 760 tons to 170 tons. Ample magnetic and acoustic signatures.

SWIMMERS AND SWIMMER COUNTERMEASURES

Objective. The objective of the Swimmers and Swimmer Countermeasures Group was to investigate the common missions of both government and guerrilla swimmers within the overall environment in which they must be carried out, in order better to evaluate deficiencies in present swimmer equipment and weapons and to determine the most practical and effective approaches to the selection and development of badly needed swimmer countermeasures systems.

Swimmer Countermeasures

Conclusions

1. To date, Viet Cong swimmers have rarely been encountered in South Viet Nam. It is believed that the following factors have contributed materially to this fact:

A. In the case of river patrol craft there have been simpler, more direct methods of attack, i.e., the controlled mine and the ambush. Further, the control and discouragement of movement along inland waterways, and possibly the capture of arms and ammunition, rather than the simple destruction of such craft in their anchorages, appears to have been the guerrilla's primary goal.

B. The lack of significant swimmer activity against major shipping in such harbors as Saigon may be due to the fact that the Viet Cong do not consider such attacks to be in their political interest at this time. Certainly this condition is not due to any lack of vulnerability on the part of ships in those harbors.

C. Finally, swimming is not a popular pastime among the people of that area. This may serve to discourage the use of a swimmer if another method will accomplish the same purpose. However, it is not believed that this will prevent the use of swimmers, and in large numbers, if they can more effectively accomplish the desired mission.

If these conditions change, an increase in swimmer attacks can be expected and, unless effective countermeasures are developed, these attacks will be largely successful.

2. Should such attacks occur, they are not likely to involve highly trained swimmers using sophisticated equipment. While SCUBA gear is easy to obtain and use, a surface approach, possibly with a breath-hold dive at the target or to avoid detection, will probably be used. Water entry will be as close to the target as is practical, possibly even from the pier against which the ship is docked. Explosive charges will be of simple, but effective design.

Recommendations

No effective swimmer countermeasure system exists at present, and the development of such a system will require considerable research and development time. Therefore, Project PEBBLE first considered those measures which might be taken against the immediate and near future problems in such areas as South Viet Nam. The following recommendations were reached:

1. As long as the swimmer activity in South Viet Nam remains at the present level, the establishment of elaborate defensive measures does not appear to be justified.

2. Full use should be made of the intelligence network in an attempt to detect plans for isolated swimmer attacks before they materialize.

3. The extensive use of alert sentries on the ships as well as in and around the harbor area is the most practical and effective precaution that can be taken under present conditions.

If swimmer activity should increase above the present level, the following additional steps should be taken:

4. Efforts should be made to channelize the swimmer's possible approaches to potential targets insofar as this is possible and practical. If this can be accomplished to any significant degree, then sharpened stakes and nets, strategically placed, should be employed as a hindrance. The net presently used by the British should be evaluated for this purpose.

5. The AN/UQS-1 and AN/SQS-19 sonars have demonstrated a detection range of 200 to 300 yards against a submerged swimmer and some detection capability against a surface swimmer. The AN/SQS-37, a few of which are now in South Viet Nam, also has a limited swimmer detection capability. Since they are available, these sonars should be pressed into service.

6. If these measures do not provide an adequate defense, it will be necessary to go to hand-thrown and randomly spaced explosive charges as an additional deterrent. When dealing with determined and highly motivated swimmers, the effectiveness of this measure should not be overrated.

7. The value of periodic hull searches by swimmers under present conditions is questionable since the time delay on charges set by the guerrilla is not likely to exceed a few minutes. An anti-withdrawal device will probably not be employed on these charges.

Needless to say, the combined use of these measures will only provide a partial defense against a determined swimmer campaign. This only serves to further emphasize the fact that an effective swimmer countermeasure system is badly needed. We recommend two basic approaches as offering the greatest potential effectiveness. Before presenting these recommendations, the point should be made that while the guerrilla and conventional swimmer may differ as to level of training and sophistication of equipment and weapons, the countermeasures problem is basically the same. Thus, the following recommendations have application to Conventional as well as Guerrilla Warfare.

1. It is recommended that tests be conducted to determine the feasibility of using an electric field in brackish and fresh water areas to deter swimmers. Our calculations indicated that under these low salinity conditions, a ship can generate sufficient power to protect itself against swimmer penetration.

2. It is firmly believed that for general application, acoustic detection coupled with a simple kill system offers the greatest potential effectiveness. No presently available sonars provide the required level of effectiveness. It is, therefore, recommended that the present effort at the U.S. Navy Mine Defense Laboratory be accelerated and that a parallel effort be initiated.

Swimmers

Conclusions

1. During Phase II operations the government swimmer, operating within his own country, will probably be limited to such missions as mine disposal and reconnaissance and will rarely be used for attacks against military targets. Therefore, existing U.S. swimmer equipment, for use in such areas and for such tasks, appears to be adequate.

2. In those areas where government swimmers are required to operate in enemy territory for purposes of reconnaissance or attack on military targets, their requirements more nearly approach those of U.S. swimmers. Project PEBBLE's recommendations, therefore, refer to the needs of both groups.

Recommendations

1. Improvement is needed in such standard equipment as launch and recovery vehicles, breathing gear, compasses and depth gauges. Work is presently going forward in most of these areas. It is recommended that support be increased in order to speed these needed improvements.

2. It is recommended that a light-weight impervious cloth suit, so designed that it shields the body fully from the biological organisms of contaminated water, be developed for use by swimmers operating in tropical regions.

3. Swimmers and mission planners should be made fully aware of the medical hazards in the area in which they are to operate.

4. Swimmer missions are frequently limited by the amount of explosives that can be carried. A research effort should be directed toward the following areas:

A. Improved demolition containers with lower drag.

B. Improved explosives. Sheet explosives and lithium-aluminum compounds should be investigated. The recommended feasibility study on the use of FAX in limpets to provide buoyancy and additional explosive energy (see Mines and Mining), is reemphasized here.

C. The versatility and effectiveness of swimmers should be increased by the provision of nonexplosive destructive materials such as gas tank additives, battery wreckers, embrittling agents, etc.

D. Finally, it seems reasonable to expect that the level of the swimmer countermeasures effort on the part of other countries will reflect any increase in the use of swimmers against them. Therefore, in anticipation of a possible increase in the difficulty of swimmer missions, particularly those against shipping, it is recommended that a low-level research effort be directed towards the development of a family of stand-off weapons.

MINE COUNTERMEASURES

Objective. The objective of the Mine Countermeasures Group was to evaluate the design characteristics and tactical use of those mine types most frequently used by guerrilla forces, and from this evaluation, to determine those countermeasures systems and techniques which promise the greatest degree of effectiveness against these mines under the physical and political environments of existing and probable guerrilla wars.

Conclusions

1. In the firm belief that an effective swimmer defense is the best countermeasure against the types of limpet mines likely to be encountered in Phase II Guerrilla Warfare, limpet mine countermeasures were not subjected to detailed analysis under this section.

2. It was concluded that shallow water coastal mines, whether for anti-assault or harassment purposes, will be a significant threat only in Phase III operations. This conclusion stems from the belief that the guerrilla is not likely to have the necessary mining resources to plant an effective field in shallow coastal waters unless he has considerable support from a major power. In addition, the likelihood of his having the requirement to plant such a minefield under Phase II conditions is considered to be very small.

However, while countermeasures against extensive coastal mining are excluded from detailed consideration in this Study, Project PEBBLE recognizes the threat that exists from mines in shallow coastal waters of interest for amphibious assaults in the Phase III-Limited War environment. Means currently exist for countering mines in water depths greater than 20 feet, but capabilities in shallower waters are considered uncertain. This problem should be fully recognized and it is suggested that the following action be taken:

A. The capabilities of the Underwater Demolition Teams for performing mine clearance tasks in amphibious assault areas should be re-evaluated from a quantitative standpoint.

B. The present effort in explosive clearance should receive active and continuous support leading to the development and procurement of an operational system.

3. Acoustic and pressure influence mines are not considered likely types for use in Guerrilla Warfare. Such mines are of complex design, have questionable target selectivity for the guerrilla's purposes, and would have to be supplied by a major power.

4. There is some likelihood of simple magnetic influence mines being used in Phase II operations. In areas where the magnetic signature of the military craft is significantly different from that of civilian craft, such mines would be capable of satisfying the guerrilla's requirement for target selectivity.

5. Present mine countermeasures capability is adequate for clearing conventional mines if these should be planted in the relatively deep water of channels leading to major harbors. It was concluded that, because of the difficulties involved, mines under the direct control of an operator would probably not be used in such relatively deep waterways.

6. In the shallower waters of relatively narrow rivers and canals, the controlled mine is by far the most likely mine type to be encountered. In areas where target selectivity is not a major consideration, moored contact or bottom mines with contact float or an upward extending contact arm are likely to be encountered.

7. Of those mine types encountered in Guerrilla Warfare, the land mine is by far the more important and, here again, the controlled mine plays the most important role. Pressure actuated land mines of simple design, under conditions where target selectivity is not a problem, is the next most likely type to be encountered.

8. Guided by the above conclusions, Project PEBBLE focused its investigation of mine countermeasures systems and techniques on the problems associated with those mines listed under Conclusions 6 and 7.

9. The great extent of mineable roads and waterways, and the guerrilla's practice of planting mines just prior to the passage of the target, makes it impractical to sweep and maintain sterile on a routine basis. Therefore, all mine countermeasures vehicles should be capable of traveling immediately in advance of the convoy and at convoy speed.

River and Canal Mine Countermeasures

Recommendations

1. Given favorable bottom conditions, tests both in the United States and South Viet Nam have demonstrated the effectiveness of the chain drag in cutting the wires leading to controlled mines. The continued use of this equipment in that area is heartily endorsed. It is recommended that similar gear, but with significantly reduced drag, be developed for use by smaller boats at higher speeds.

2. No capability exists at present to sweep moored contact mines or bottom mines with contact arms such as those envisioned in this Study. Therefore, it is recommended that a simple two-boat wire sweep be developed for this purpose. Used in conjunction with the chain drag against the controlled mine (which is usually suspended above the bottom), the wire sweep, riding close to but above the bottom, has the advantage of providing a better indication of the mine's presence so that action against the operator can be taken, and of allowing neutralization of the mine to prevent its reuse.

3. A clear and pressing need exists for a good minehunting sonar with high reliability and of relatively simple design, for use on river patrol craft. The development of such a sonar, suitable for the detection of river and canal mines, is both feasible and practical. It is strongly recommended that a program aimed at the development of the needed sonar be initiated at once. The objective of this program should be to develop the best, simple, reliable and easy to operate sonar that is capable of providing high detection probability at the maximum range compatible with the detection probability requirements.

The following actions are recommended as a part of this development program:

A. The AN/SQS-37 sonars now in South Viet Nam is a "quick-fix" system having a detection range of about 100-120 yards at speeds of 4-6 knots. This range is considered marginal by operators because it provides insufficient reaction time under the operating conditions of that area. However, this sonar does provide a detection capability where none existed before. To provide this capability, and to obtain performance data highly valuable to the development of the recommended sonar, the continued use of the AN/SQS-37 by well-trained operators is strongly encouraged.

B. The AN/SQS-37 has never been given a thorough laboratory evaluation; thus, its performance characteristics are not sufficiently well

known. Such an evaluation should be conducted, first with the present system and then with an add-on range analyzer and visual display. The results of this evaluation will contribute valuable input data to the recommended development program.

C. Experiments should be conducted with higher frequency operation to gain improved resolution consistent with the range requirements.

D. Comparison tests should be run with CTFM and elementary pulse sonar.

E. Existing sonars, such as the AN/SQS-19, Honeywell Sea Scanner, and Straza 500 CTFM sonar, should be evaluated by a laboratory.

4. It is also recommended that a longer range program be initiated to develop a high-frequency, high-resolution side-looking sonar for use in rivers and canals. This sonar should be extremely simple, with high performance (4 inch x 3 inch resolution) but short range (50 to 60 feet). Such a sonar is recommended for use with one or two escort mine countermeasures boats searching ahead of the convoy.

5. Present minesweeping gear, such as the chain drag and grapnel, give no indication of the mine's presence even if the control wires are cut. The advantages of knowing that a mine has been encountered and swept were mentioned above. It is, therefore, recommended that a research and development project be undertaken to develop a simple towed device for use in conjunction with the chain drag to provide an indication that control wires have been encountered. Three approaches are recommended for consideration: (1) a dc bridge detector, (2) a mutual inductance bridge detector (modification of the Army's Small Metals Detector), and (3) an rf detector. Used with a directional antenna, the latter approach would permit the general location of the mine operator to be determined.

6. Magnetic detectors have been developed to an advanced stage, but against the mine types of interest here the range is still only eight feet. In addition, they are fairly complex to adjust and use. Therefore, we do not recommend the development of a magnetic detector for river and canal mine detection at this time. It should be kept in mind, however, that this may be the only method capable of detecting buried ferrous mine cases, should this ever become a problem.

7. Finally, Project PEBBLE considers it essential that a lead laboratory for river and canal mine countermeasures be established. The

laboratory should, of course, have a long range research and development program, but of greater importance should be the capability of fast reaction to immediate needs. The laboratory selected should have adequate test sites in which the physical environmental conditions are similar to those in areas of interest in Counter-Guerrilla Warfare. Also, means should be provided for maintaining continuous close liaison with the theaters of operation. A highly portable laboratory, installed in one or more vans for operation within the area of conflict, would make a valuable addition to and extension of the lead laboratory.

Land Mine Countermeasures

Recommendations

Comprehensive data on the number and nature of land mining incidents in South Viet Nam do not appear to exist. However, it may be stated with confidence that in this conflict, as well as guerrilla wars in general, the land mine in its many forms is by far the mine type of greatest importance. Fall,* for instance, states that 84 per cent of the 385 French land vehicles lost in Indochina over a two-year period were due to land mines as defined by Project PEBBLE.

The controlled river and canal mine is only occasionally used as a means of immobilizing a convoy or throwing it into a state of confusion in order to make an ambush more effective. The controlled land mine, on the other hand, is almost always used for this purpose in ambushes against truck convoys.

The threat posed by the land mine to counter-guerrilla operations is further magnified by the fact that no even reasonably effective countermeasure exists at present. Regrettably, Project PEBBLE, in spite of considerable effort, was unable to arrive at an adequately effective solution to this critical problem. The following actions are recommended as a means of providing some increase in capability.

1. It is recommended that a special escort or precursor vehicle equipped with a modified version of the Army's Small Metals Detector and capable of traveling at convoy speed be developed.

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*Fall, Bernard B. Street Without Joy, 4th rev. ed. Harrisburg, Pa.: The Stackpole Company, 1964.

2. A special guinea pig vehicle, capable of traveling at convoy speed and withstanding several mine blasts, should be developed. Such a vehicle would, of course, trigger pressure actuated mines, but should also be designed so that it appears as a desirable target to the controlled mine operator.

3. The emphasis within the research and development program for land mine countermeasures should be shifted so as more reasonably to reflect the fact that the needs of Guerrilla Warfare are immediate while those of large scale Conventional Warfare are of a long-range and less predictable nature.

4. As previously mentioned, the land mine frequently plays an important part in the most effective tactic of a military nature consistently employed by guerrilla forces — the ambush. Project PEBBLE strongly believes that the development of counter-ambush weapons and tactics, including mine countermeasures as an important part, should occupy a position of highest priority. Considerable effort is presently being devoted to this task by several groups. It is recommended that a small group be established to evaluate and coordinate these efforts and to develop new approaches to the problem.

5. Finally, it is strongly recommended that efforts to obtain detailed field reports on both land, and river and canal mining incidents be greatly increased. The data contained in such reports would be invaluable to the research and development program for mine countermeasures.

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13. ABSTRACT

The Project PEBBLE Study Group investigated the problems of mine warfare as employed and encountered in Phase II of Guerrilla Warfare. Mine types covered were: (1) land mines, (2) river mines, (3) shallow-water coastal mines, and (4) limpet mines. Major areas covered by the study were: (1) The Political, Social, Economic and Psychological Environment, (2) Physical Environment, (3) Waterborne Vehicles, (4) Mines and Mining, (5) Mine Countermeasures, and (6) Swimmer and Swimmer Countermeasures. Conclusions and recommendations resulting from the study are presented.

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